INERTIAL CONFINEMENT FUSION
Lawrence Livermore National Laboratory
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Bimonthly Update

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Scintillators for Down-Scattered Neutron Imaging

In ICF implosions, the imploded DT hot spot emits principally 14.1-MeV neutrons from the (D,T) fusion reaction. Imaging the 14.1-MeV neutrons by pinhole or penumbral aperture techniques provides a 2D image of the burning hot spot and fuel. Moreover, recent hydrodynamic simulations have demonstrated that unique and valuable data on the spatial structure of colder, denser outer fuel layers that may not burn during our first attempts at ignition may be obtained by imaging lower-energy neutrons that have undergone near-90° scattering while transiting the outer fuel layer. Simulated

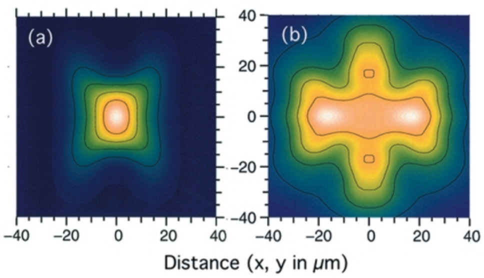

Figure 1. Neutron images: (a) 14.1 MeV and (b) 6.7 MeV.

neutron images (Fig. 1) of an intentionally degraded nonigniting NIF implosion compare a 14.1-MeV centrally peaked neutron image (Fig. 1a) with a 6- to 7-MeV down-scattered neutron image (Fig. 1b). The down-scattered neutron image contains valuable information on compressed fuel asymmetries that cannot be obtained from the 14.1-MeV image.

Conceptually, it should be straightforward to record the image cast on a distant scintillator by the slower down-scattered (and hence later-arriving) neutrons by just using a shuttered camera. However, in practice the down-scattered neutrons must be recorded after the scintillation detector has been exposed to the much brighter (factor of 1000 greater) 14.1-MeV neutron flash. We have therefore initiated experiments to characterize the long-time decay characteristics of several potentially suitable neutron scintillators.

Figure 2 shows the measured scintillation decay curve of a plastic scintillator, BC-422, after irradiation by 14.1-MeV neutrons. The data show that the scintillation intensity has decayed by

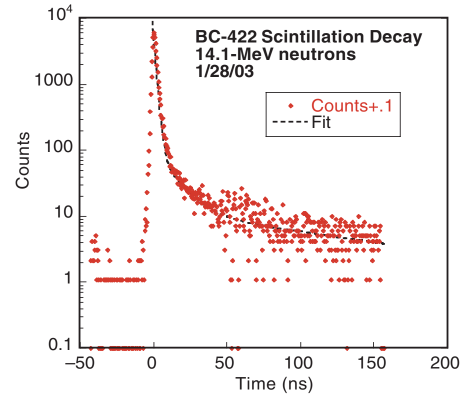

Figure 2. BC-422 scintillation decay.

slightly more than the required factor of 1000 150 ns after the neutrons strike the scintillator. This delay time will correspond to the arrival time of 8-MeV down-scattered neutrons for a detector 25 meters distant from a NIF implosion, sufficiently close to provide bright neutron images. Future experiments will study other candidate scintillators, the potential benefits of narrow-bandwidth filtering for further discriminating between prompt scintillation and long-time decay, and compare the scintillator sensitivity at different neutron energies.

Time-Resolved Neutron Detector Array Reactivated at UR

The 1024 neutron detector array (also known as TION) was designed and built by Los Alamos scientists for use at LLNL's Nova laser facility, and it will eventually serve as a neutron spectrometer at the NIF. The name "1024 array" derives from the 1024 photomultiplier / scintillator detectors that measure neutron flight times in single-hit mode as a method of recording neutron energy spectra. After Nova was decommissioned, the 1024 array sat idle, but in preparation for its use at NIF, it was recently returned to active status and recorded neutron spectra from ICF implosions at the University of Rochester's

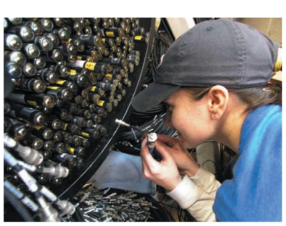

Figure 1. Student refurbishing TION.

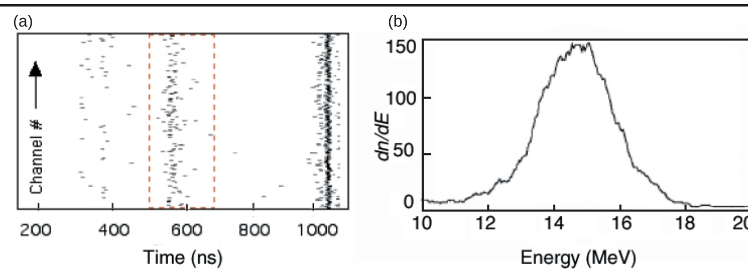

Figure 2. (a) TION event data vs time. (b) Secondary neutron spectrum extracted from (a).

Laboratory for Laser Energetics (LLE) OMEGA laser facility.

An LLE physicist and several State University of New York at Geneseo undergraduate students refurbished the system including operational verification, repairs, and recalibration. Figure 1 shows a student reinserting one cable into the front of the array, while another assists from below.

Figure 2 displays a sample of the data now being recorded by the 1024 array from a pure deuterium fusion experiment. Figure 2a shows about 25% of the raw temporal data recorded by individual detector channels. Data is recorded as the times of events in the detectors. The different groups of "hits" are associated with neutron-induced gamma rays, secondary (centered around 14.1 MeV) neutrons, and primary (2.5 MeV) neutrons. In Fig. 2b, the time distribution of events from the central part of the data (representing the secondary neutrons, inside the red rectangle) has been converted into the "secondary" neutron spectrum. The return of the 1024 array to active status puts in place one important part of the plan for neutron diagnostics at the NIF.

For comments about content of the ***Bimonthly Update,*** contact Bruce A. Hammel (925) 422-3299.
To get on the mailing list of the *LLNL ICF Program Bimonthly Update and Annual Report* send a request to miguel1@llnl.gov
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